EXports Writing Team: Mike Behrenfeld (OSU), Claudia Benitez-Nelson (USoCar), Emmanuel Boss (UMaine), Mark Brzezinski (UCSB), Adrian Burd (UGA), Craig Carlson (UCSB), Eric D’Asaro (UW), Scott Doney (WHOI), Mary Jane Perry (UMaine), Rachel Stanley (WHOI), Deb Steinberg (VIMS)
What is EXPORTS?

A community-vetted science plan for a NASA field campaign

Predict the **state** of the biological carbon pump from satellite (and maybe other) observations

Final Science Plan Submission: June 2014
Projected start date: 2017 (if approved)
Why EXPORTS?
**Why?** Need to understand, quantify & predict how ecosystem processes transfer organic matter to depth.
Why? Improve global estimates of carbon export from the euphotic zone (4 to >12 Pg C y\(^{-1}\))
Why? Need to quantify the attenuation of export below euphotic zone (the twilight zone)
Why Now? Advances in remote sensing (& PACE!!) & autonomous tools make it time!
Exports: Focus on Pathways

Summing over the pathways gets 5 to 12 Pg C y\(^{-1}\)

0.5 - 2.5 Pg C y\(^{-1}\)

4 - 8 Pg C y\(^{-1}\)

0.5 - 1.5 Pg C y\(^{-1}\)
EXPORTS: Observing the Biological Pump’s Pathways

Seek a **mechanistic understanding** of the **pathways** driving the biological pump

Needed for **building models and predicting** present & future states of the biological pump

**Goal:** Predict the state of the biological pump given surface ecosystem characteristics
Different Pathways for Different States

North Atlantic Bloom

Large phytoplankton

Large export flux from the Euphotic Zone

Weak flux attenuation in the Twilight Zone
Different Pathways for Different States

Northeast Pacific Summer

Small phytoplankton & microbial loop dominance

Weak export from the Euphotic Zone

Strong flux attenuation in the Twilight Zone
EXPORTS: Three Science Questions

How do plankton community composition & ecological-physical interactions determine the vertical transfer of organic matter from the well-lit surface ocean?

What controls the efficiency of vertical transfer of organic matter below the well-lit surface ocean?

How can the knowledge gained be used to reduce uncertainties in contemporary & future estimates of the biological pump?
**EXPORTS: Experimental Plan**

**Station P**
- Cruise 1: April/May 30d (40d survey)
- Cruise 2: Aug, 30d
- Leverage: OOI node, LineP

**North Atlantic**
- Bloom: April/May 45 d
- Non-bloom: Aug, 30d
- Leverage: PAP & other international partners

Will collect up to 8 states of the biological pump
EX jeunes: Experimental Plan

Data Mining

Compile secondary datasets of more biological pump states from other sites

Extends the number of “states” available for modeling building

Examples include: BATS, HOT, CARIACO, VERTIGO, MAREDAT etc.
**EXPORTS: Experimental Plan**

- **Water-following**
  - follow instrumented mixed layer float(s?)

- **Follow Particles**
  - from production to trap
  - Measure C cycling fluxes from 0 to 500 m (over 10 d)

- **Lagrangian Ship**
  - Measure rates & transformations

- **Spatial Ship**
  - Submeso- & meso-scale surveys (5-200 km)
  - Deploy short-term assets

- **Long Term Presence**
  - Profiling floats (& Satellites)
  - BioARGO, PSD & export proxy
  - Annual BGC budgeting
  - $O_2$, $NO_3$, DOC, DIC, etc.

- **Optimize Spatial Sampling**
  - Gliders surveying (5-100 km)
  - Bio-optical proxies
  - Satellite sampling
  - Ocean color & supporting
EXPORTS: Experimental Plan

Two Ships
“Lagrangian”
“Spatial

Autonomous Array
Mixed layer float
Glider surveying
Drifting traps
Multiple floats

Bio-Argo, PSD, export
**Process & Survey Cruises** - includes multi depth trapping, rates, tow-yo SMS mapping, zooplankton tows, full bio-optics, etc.

- **= Process & Survey Cruises**
- **= deploy autonomous assets**
- **= recover autonomous assets**

**Autonomous Assets**
- **Floats**: 3 types (Bio-Argo; PSD; flux)
- **Gliders**: 2-Meso- & 2-Process-scale
- **Process**: ML float, TS traps

**Timeline**
- **2017**: Data mine Modeling
- **2018**: NE Pac
- **2019**: data process/regroup
- **2020**: NE Atl
- **2021**: ANA
- **2022**: EXports End 5 years
EXPORTS: Observables

Ecosystem Structure: Community Characteristics
EXPORTS: Observables

Ecosystem Function: Physiology, rates, processes
EXPORTS: Observables

Multiple paths to export & its attenuation with depth
EXPORTS: Observables

Water Column Characterization

Ocean Optics:
\( R_{rs}(\lambda), E_d(z,\lambda), \) IOP’s, PSD, etc.

Biogeochemistry:
Nuts, DIC, DOC, POC, PIC, etc.

Physical Oceanography:
T, S, horizontal velocity, etc.
**EXPORTS: Technical Readiness**

**EXPORTS can** answer its science questions with present technology

**Improvements that would be nice...**

**Experimental Logistics:**
- OSSE’s & tools for coordinating sampling, etc.

**Rapid Plankton Characterization:**
- omics, imaging, acoustics, cell sorting, etc.

**Sensors for Autonomous Platforms:**
- Zooplankton abundance/composition, DIC, DOC, PSD, etc.

**Optical Instrumentation** (aimed for PACE):
- Hyperspectral reflectance, UV IOP’s, etc.
**EXPOSURS Budget: $53M, 5 years**

**Autonomous Array:**
- 6 × 4 floats
- 6 gliders (4 spares)
- 2 ML floats (1 spare)
- 9 traps (3 spares)
  - $5.3 million

**Ships:**
- NE Pacific (154 d)
- N Atlantic (180 d)
  - $13.8 million

**Investigators:**
- 20 PI groups & equipment
  - $27 million

**Other:**
- Logistics, project/data man, etc.
  - $5.8 million (12%)

- autonomous array (10%)
- ships (25%)
- investigators (52%)
EXPORTS: Budget

Yes, this is a large request. **BUT** $53 million is in line with most NASA field campaigns & U.S. JGOFS process studies.

**Descoping & Rescoping:** Modularity of the EXPORTS science plan makes this easier.

**Partnering will be critical:** Both within the U.S. and internationally.
EXPORTS: Next Steps

Draft comment period has ended and ~30 written comments are being assimilated into final report.

Final Science Plan will be submitted to NASA in June followed by formal comment period (60 d) & panel review.

If selected: A Science Definition Team will be competed (late-2014) to write the Implementation Plan with the EXPORTS field campaign starting 2017.

Important: Every role in EXPORTS will be competed!!
EXports Writing Team: Mike Behrenfeld (OSU), Claudia Benitez-Nelson (USoCar), Emmanuel Boss (UMaine), Mark Brzezinski (UCSB), Ken Buesseler (WHOI), Adrian Burd (UGA), Craig Carlson (UCSB), Eric D’Asaro (UW), Scott Doney (WHOI), Mary Jane Perry (UMaine), Dave Siegel (UCSB), Rachel Stanley (WHOI), Deb Steinberg (VIMS)

http://exports.oceancolor.ucsb.edu
EXTRACTIONS: *Notional* Timeline

- **2014**
  - Ocean Sci Meeting
  - Final Report Submitted
  - Peer Review Panel Completes
  - NASA SDT ROSES Call

- **2015**
  - NASA SDT Completes
  - NASA EXPORTS ROSES Call

- **2016**
  - EXPORTS Starts
  - Data mine Modeling

- **2017**
  - NE Pac
  - Jan [10]
  - May [40 S]
  - [30 P]

- **2018**
  - Sep [30]
  - Mar? [10]
  - data process / regroup

- **2019**
  - EXPORTS Ends

- **2020**
  - NE Atl
  - Jan [10]
  - Apr/May [45]
  - Aug [30]
  - data process/ synthesis

- **2021**

*UNOFFICIAL – NOT APPROVED!!!*